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Looking into the Danish energy system: Lesson to be learned by other communities

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ABSTRACT

Industrialization, development and social transformation has brought together issues of over exploitation of limited energy resource base (e.g. fossil fuel), accelerated threats of energy insecurity, and liberation of greenhouse gas emissions across the continents. The global challenge for the 21st century and way ahead is to find other means of satisfying energy needs, diversifying the energy supply, up-scaling the make-up of renewable energy to a greater extent, optimization of energy consumption and supply system. Denmark has been continuously moving towards optimization of energy production, usage and its overall management, during and even after the first global oil crisis. The country has been delivering its priority in the development of renewable energy and standing the country an energy self sufficient from last three decades. Country's overall consumption of energy has decreased than that of the decades of 1980 and 1990s, with wider range of energy mix and saving options. The Danish government has strategized to make the country fossil fuel free by 2050, where special attention and interventions is required to boost up its development of renewable energy in the country. The past efforts of the Danish government in the energy development has helped not only making the country 'energy self sufficient', but also lowering the level of carbon dioxide in the atmosphere. Danish energy policy and strategies have been found more conducive and reflective of the joint EU priorities on the matter of dealing with climate change and energy security. All the past progress and its allied policies seem to be quite supportive in fulfilling its strategies for greener future. This review paper will discuss on the past efforts of Danish government in energy management and highlights on some political initiatives, which have been realised to support the country moving towards clean and green energy future.

Contents

1. Background

In the current rapid growing economy, *energy and environment* are crucial challenge to manage. After the energy crisis of 1970s, there have been a number of efforts to address and maintain secure energy systems, including consumption and supply around the globe. With the increase in the process of industrialization, development and social transformation, pace of energy exploitation and consumption has increased rapidly, which is eventually leading towards insecure energy supply systems (limited resource base of fossil fuel, on which majority of economic activity is based) and

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also increased liberation of green house gases (GHGs) in the open atmosphere.

The Kingdom of Denmark, which is regarded as "Energy Self Sufficient Country" is situated in northern Europe with a population of about 5.4 million people. The annual population growth of the country is 0.3%, with its population density of approximately 125 persons per square kilometre. It has a land mass of 43,098 sq. km in the middle of northern Europe with adjoining neighboring countries like Germany to the south, Norway lies to the north and Sweden to the north-east [1,2].

The paper will have its pace on looking towards past energy interventions in the Danish Energy system and on how it can hopefully support in fulfilling the renewable energy based economy in future, which could also be a lesson to other developing and developed countries as well.

2. Energy issues and climate change

The world is facing a new era of energy crisis. Many European societies were largely driven by access to cheap and plentiful coal, oil and gas in the 20th century. The global challenge for the 21st century and way ahead is to find other means of satisfying energy needs, diversifying the energy supply, making the make-up of renewable energy to a greater extent, optimization of energy consumption and supply system and ensuring the global connectivity of supply chain of renewable energy.

It is expected that within the next 25 years, the world's total energy consumption may increase by one-third; this will accelerate the increasing pressure on fossil fuel. It may have affect on the economy as whole, where there will be influence and growth opportunities of regions largely depend on their access to fossil fuels, with increasing prices and uncertainty as a consequence [3].

The Riso-National Laboratory, in one of its publication [4] had stated following challenges:

- There is high probability that EU carbon dioxide (CO_2) emissions will rise by approximately 5% by 2030, if no actions are taken in the energy and transport policy. This was indicated at the period of 2007.
- Existing trends imply that the present import share of 50% will increase to approximately 65% by 2030. This will make Europe's energy system more vulnerable to external factors that are difficult to control.
- Rising energy prices could jeopardize job creation in the EU. Investing in energy efficiency and renewable energy could promote innovation and industrial development, with corresponding benefits for employment and the economy [4,5].

These challenges realised in 2007 also forwarded a message that the present energy policies within the EU are not sustainable [5].

According to the Intergovernmental Panel on Climate Change (IPCC), satisfying the objective of stabilizing greenhouse gas concentration in the atmosphere at a level corresponding to a global average temperature rise below 2 °C, which was proposed at Copenhagen Accord (COP 15) and confirmed at Cancun (COP 16), requires the developed countries to reduce their combined emissions. It has stated that such reductions should be at the range of 25–40% by 2020 relative to 1990 levels, and 80–95% by 2050 relative to 1990 levels as a step towards cutting global emissions by 50% by 2050. The EU has committed to the objective of reducing emissions by 80–95% by 2050 relative to 1990 levels as a part of concerted efforts by the developed countries [4].

Considering the need of massive intervention at the local and regional level to cut down the emissions and build up the energy security level, every adjoining members of EU should have conducive energy plans and policies and implementation strategies.

3. Looking into Danish energy situations

Realising the impact of climate change as mentioned being a serious problem by the United Nations' International Panel of Climate Change (IPCC), many countries have been found developing their respective policies in energy management to reduce the emission of carbon dioxide (CO_2). In this context, in March 2007, the European Union (EU) has also strategized to have an energy target of 20% through renewable energy by 2020.

Denmark has set up a target of 30% renewable energy in its total stake of energy consumption by 2025. The latter Danish government strategy in the energy system has been shifted to cleaner regime, which spells that 100% of renewable energy may exist by 2050, by eliminating the consumption of fossil fuel [1,2]. It has also been found that supply of 100% of renewable energy in the Danish energy system is physically feasible, but at the meantime the most crucial issues identified is the degree that the country can depend on renewable energy sources/technologies considering the production efficiencies [6].

Even after the first oil crisis in 1973, Denmark has been enjoying ensured and secured energy supply, which is because of its fundamental retrofitting of energy systems, integration of energy policies to promote clean energy technologies, advancement towards energy efficiency and saving measures. Shift in Danish energy system has been found not only in households' level, but also through energy efficiency and promotion of District Heating System, Combined Heat and Power (CHP) plants and adopting a fuel mix approach like changing from 95% of imported oil dependence to a differentiated energy supply based on coal, natural gas and renewable energy [3].

Denmark is a minor producer (about 290,000 barrels per day in 2008) of oil compared to Norway and United Kingdom from the available reserves of the North Sea oil. Denmark is also regarded as an oil exporting country, particularly to Sweden, where in 2007 about 100,000 barrels per day (i.e. 30% of its oil) were imported from Denmark [7]. The connectivity of energy security with dependency on oil reserves should be carefully looked not only in the domestic domain but also in the periphery of the consumer who is dependent on the depleting fossil fuel reserves. It has been reported that an average annual decline of the Danish big oil reserves to be 6.7%, however it is lower than that of adjoining countries as Danish lower ground strata have lower permeability due to presence of lime [7].

In the past last two decades, Denmark has been found developing and implementing different interventions of sustainable energy development, in one hand comprised of energy saving measures (efficient energy building construction, improving insulation of buildings, and improvement in the efficient energy production in its cogeneration power systems), and in other hand development of renewable energy technologies in a massive scale (construction of wind power technologies and installation) [8,10,11].

3.1. Energy consumption and production

Of the Danish gross energy consumption (814 PJ) at 2009, about 28 percent is consumed at household sector, followed by transport (26%), agriculture and industry (23%), trade and service (16%). Energy sector constitute of 6% and non-energy use have stake of about 1% on the gross energy consumption. Furthermore, IEA (2008) reported that of the total energy consumption in the residential buildings, space heating has a dominating consumption (55%), water heating has a stake of 19% and followed by appliances (19%), cooking (4%), and lighting (3%). The energy consumption

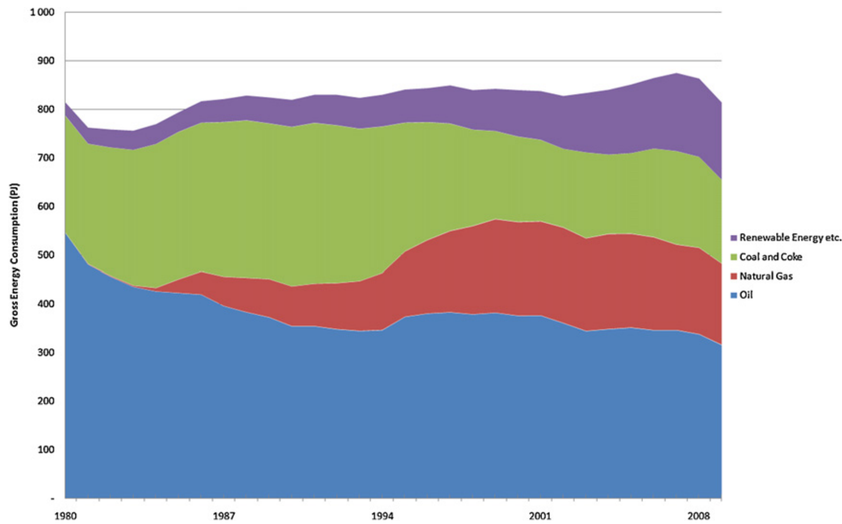


Fig. 1. Gross energy consumption by fuel source in Denmark (1980–2009).

Source: Based on database [1,9].

Table 1
Trend of gross energy consumption in Denmark (1990–2009).

Adjusted [fuel equivalent in PJ]	Years						
	1980	1990	1995	2000	2005	2008	2009
Total gross energy consumption	814	819	840	839	851	863	814
Fuels	814	819	840	839	851	863	814
Oil	546	355	374	376	352	338	316
Natural gas	0	82	134	192	192	177	167
Coal and coke	241	327	265	175	166	187	172
Wastes, non-renewable	3	6	9	13	16	17	16
Renewable energy	24	50	59	82	125	144	143
Energy products	814	819	840	839	851	863	814
Oil	446	338	335	329	333	325	301
Natural gas	0	59	83	98	100	98	92
Coal and coke	22	17	16	12	11	10	5
Wastes, non-renewable	0	0	1	1	1	1	1
Renewable energy	16	28	28	33	44	58	54
Electricity	249	297	298	286	279	288	275
District heating	73	78	79	79	81	83	85
Town gas	7	2	1	1	1	1	1
Uses	814	819	840	839	851	863	814
Energy sector	17	28	38	44	52	51	45
Non-energy use	16	13	13	13	12	11	11
Transport	144	172	186	203	218	223	211
Agriculture and industry	228	227	233	227	214	208	186
Trade and service	130	132	127	125	127	134	131
Households	277	248	243	227	229	236	230

Source: [1]

status of Denmark shows that the gross energy consumption of the country has decreased by an average rate of 0.7% from 1990–2009 [1,9]. At the meantime, there has been significant improvement in the energy efficiency in the country since 1990, particularly in the heating for the residential buildings, which consists of substitution of old oil burners with new natural gas burners and district heating [12].

During the whole past two decades, the share of energy consumption by fuel source in Denmark seems interestingly changing (Fig. 1). The Danish energy policy has been found well integrated in the development of economy, considering the environmental and economy aspects. There have been significant reductions in the consumption of oil, coal and coke consumption in these decades. On the total stake of gross energy consumption in Denmark in 2009, renewable energy shared about 18%, where it was only about 3% in 1980, 6% in 1990, 10% in 2000 and 15% in 2005 against the respective gross energy consumption in different time series. The overall picture of gross energy consumption of Denmark is depicted in Table 1. It reveals that the Danish energy policy has been changing continuously to uptake the share of renewable energy in its energy demand. It has also been found that despite of growing economy of the country, the energy consumption is almost fairly constant [1,9].

Table 2
Percentage changes in the gross energy consumption in Denmark (1980–2009) by fuel sources.

Fuel sources	1980–2009	1990–2009	2008–2009
Oil	−42.1	−10.9	−6.5
Natural gas	993,129	103.7	−6.0
Coal and coke	−28.5	−47.3	−7.7
Renewable energy, etc.	486.6	186.3	−1.3
Total	0.0	−0.7	−5.7

Source: [1].

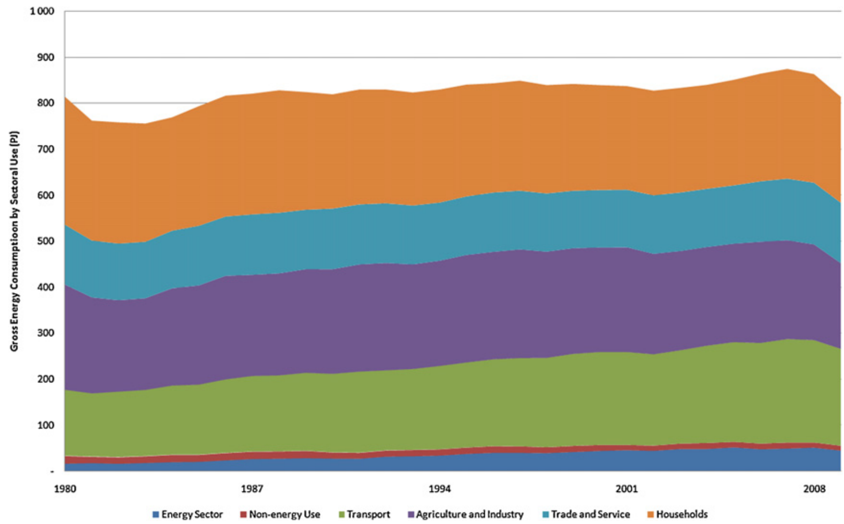


Fig. 2. Share of gross energy consumption by use (1980–2009).

Source: Based on database [1,9].

However, there have been abrupt increase in the consumption of natural gas in the early decades of 90s, its consumption has been reduced significantly in following years (Table 2). Share of renewable energy sources in the gross energy consumption has been increased attractively, when observed the overall trend of energy consumption in the past two decades [1,9] (Fig. 2).

Scale of energy production in Denmark has been increased in the last three decades. For the period of 1980–2009, the average incremental rate of the total primary energy production is about 137%. This is make up by the stake of energy sources like; crude oil (117%), natural gas (172%), waste-non renewable (219%), and renewable energy (155%) [1,9]. The trend of energy production is depicted in Fig. 3.

3.2. Carbon dioxide emissions in Denmark

The total adjusted CO_2 emissions in Denmark accounted as 62,570 ('000 tonnes) in 1990. Denmark has been found developing its economy with proper attention towards the commitment in the international climate change conventions and strategies. There has been reduction in emissions of CO_2 by about 19% in 2009 from the 1990 level [1,9]. The overall picture of CO_2 in Denmark from 1980 to 2009 is depicted in Table 3.

4. Denmark embark towards secured and green energy future

Vision and strategies of Danish Government for moving the country towards self-sufficient and green energy futures can be characterized and supported by some of the realities and initiatives. This includes the increasing threats of the country being oil and gas importers in near future. The Energy Policy Statement 2010 of Denmark has stated that despite of having higher energy production capacity (about 124%) against its total consumption, the country has higher tendency to cripple down its ratio of production to consumption, with the reduction in capacity of oil and gas production in the North Sea [13]. Under these conditions, with no invention and improvement in the efficiency in the production, the country is expected to be an importer of oil and gas from about 2018 (Fig. 4).

Considering the necessities and also looking on various plans and policies formulated and implemented by Danish Government,

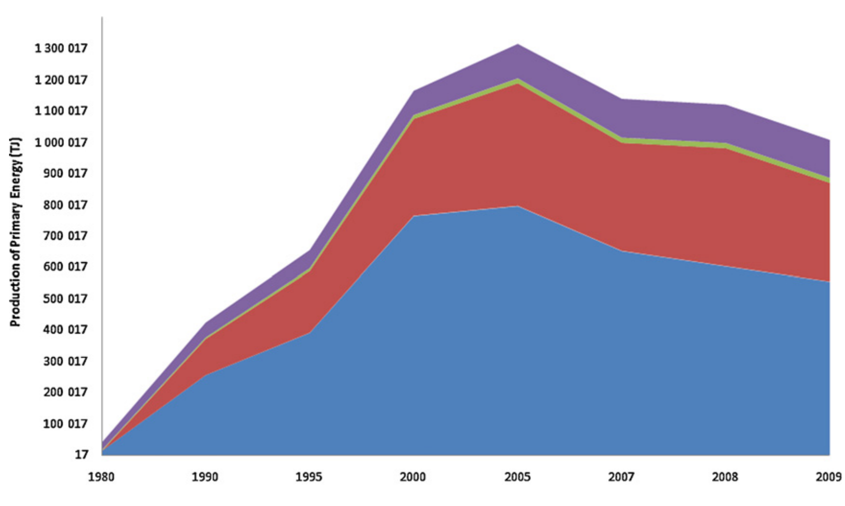


Fig. 3. Energy production in Denmark (1980–2009).

Source: Based on database [1,9].

Table 3
Adjusted carbon-dioxide emissions in Denmark (1980–2009).

Adjusted [1000 tonnes CO_2]	1980	1990	1995	2000	2005	2008	2009
Total CO_2 emissions	62,570	61,181	59,839	55,354	52,386	52,688	49,416
CO_2 emissions by fuel	62,570	61,181	59,839	55,354	52,386	52,688	49,416
Oil	39,384	25,034	26,375	26,724	24,461	23,555	22,350
Natural gas	1	4646	7603	10,955	10,955	10,050	9435
Coal	22,916	31,100	25,149	16,677	15,738	17,752	16,375
Wastes, non renewable	269	400	712	998	1232	1332	1256
CO_2 emissions by sector	62,570	61,181	59,839	55,354	52,386	52,688	49,416
Energy sector	880	1391	1884	2312	2429	2364	2307
Transformation sector	28,809	32,410	30,257	25,489	22,487	23,602	22,412
Power production	22,868	27,330	25,421	21,046	18,468	19,603	18,465
District heating production	5382	4972	4758	4398	3986	3966	3914
Town gas production	559	108	78	45	33	34	34
Final energy consumption	32,881	27,379	27,698	27,553	27,470	26,722	24,697
Transport	10,440	12,419	13,444	14,638	15,709	16,128	15,224
Agriculture and industry	10,360	7967	8154	7690	7062	6525	5676
Trade and service	2890	1531	1085	927	943	859	776
Households	9191	5463	5015	4298	3757	3211	3021

Source: [1].

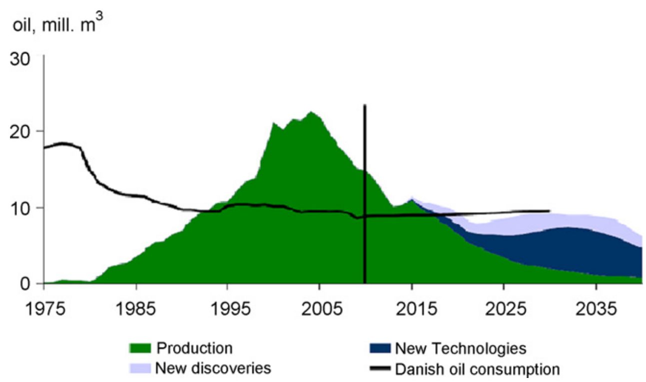


Fig. 4. Danish oil production from 1975 to 2009 and projections for 2040. *Source*: [13].

it is hopefully wise to say that the Danish strategy to reduce fossil fuel dependency is quite relevant. Some of the efforts that can be found in the boundary of Denmark, which are among the supportive elements for its greener energy future are discussed in following section.

4.1. Danish plans and policies

The Energy Policy of Denmark, 2009 has stated that the country has envisaged having its society consuming energy in an efficient manner through means of different interventions like energy savings. It has also stated that the future energy supply will be based on renewable sources [10]. The Climate Commission, established in 2008 by the Danish government is also one of the Denmark's important milestones in the path of green energy development. The Commission was established with an objective to prepare proposal on how Denmark can realise this vision of becoming a fossil-fuel-independent nation [10,11,14].

Danish energy policy and strategies have been found more conducive and reflective of the joint EU priorities on the matter of dealing with climate change and energy security. The national energy strategy for 2025 and in a numbers of country's political agreement carried out during the period of 2007–2010, elaborates on energy management perspective like; increased use of renewable energy particularly wind and biomass, increasing overall energy efficiency, reducing the consumption of fossil based oil in transport and also in undertaking research and development in renewable energy and energy efficiency. It also includes specific targets of a 20% share of renewable in the Danish energy system by 2011 and reduced gross energy consumption by 2% in 2011 and 4% in 2020 [10,11].

The Danish Government in 2010 concluded that transition to a fossil fuel independent society is highly potential, which has been expected to reach by 2050 [1,10]. With the assessment and conclusion made so far by the Danish Commission on Climate Change, the Danish Government has materialized Energy Strategy 2050, which aims to delineate the society with a vision of becoming independent of coal, oil and natural gas [3]. This strategy of the Danish Government is expected to play a positive role in supporting and materializing the commitment to the international community for drastically reducing green house gas emissions, made so far at international climate change conferences in Copenhagen, Cancun and other global political desks [13]. For the purpose of making the sustainable use of energy in the future, the energy policy of the country has highlighted the need of a green and smart society, with low energy dwellings, self sufficient (plus energy homes), which generate more energy than they consume.

Some of the initiatives of Danish government as mentioned in [10], may be supportive tools to ensure green energy shift of its community. This broadly includes;

- Initiatives for energy savings and expansion of renewable energy through the energy agreement from February 2008.
- Tax reform towards a more intelligent and green tax system, which reduces CO_2 emissions and gross energy consumption, and also promotes renewable energy.
- Subsidies for energy renovation of buildings and stricter requirements for the energy performance of buildings. Allocated of fund for renovation and construction work, including energy savings in permanent residences.
- A strategy for reducing energy consumption in new buildings presented in April 2009 by Danish Government. The strategy proposes tightening the requirements by 25% in 2010 and by 57% in 2015, combined with a provision of district heating in new buildings, where by reducing energy consumption by 50%.
- Green transport policy from January 2009, to support the long term energy strategy of Denmark through integration of other requisites like significant boost to the railways, road pricing and new sustainable technologies.

4.2. Energy features

One of the examples on energy development in the country is well justified by the progress in the electricity infrastructure from 1985 to 2009. In the days of 1985, there have been some Combined

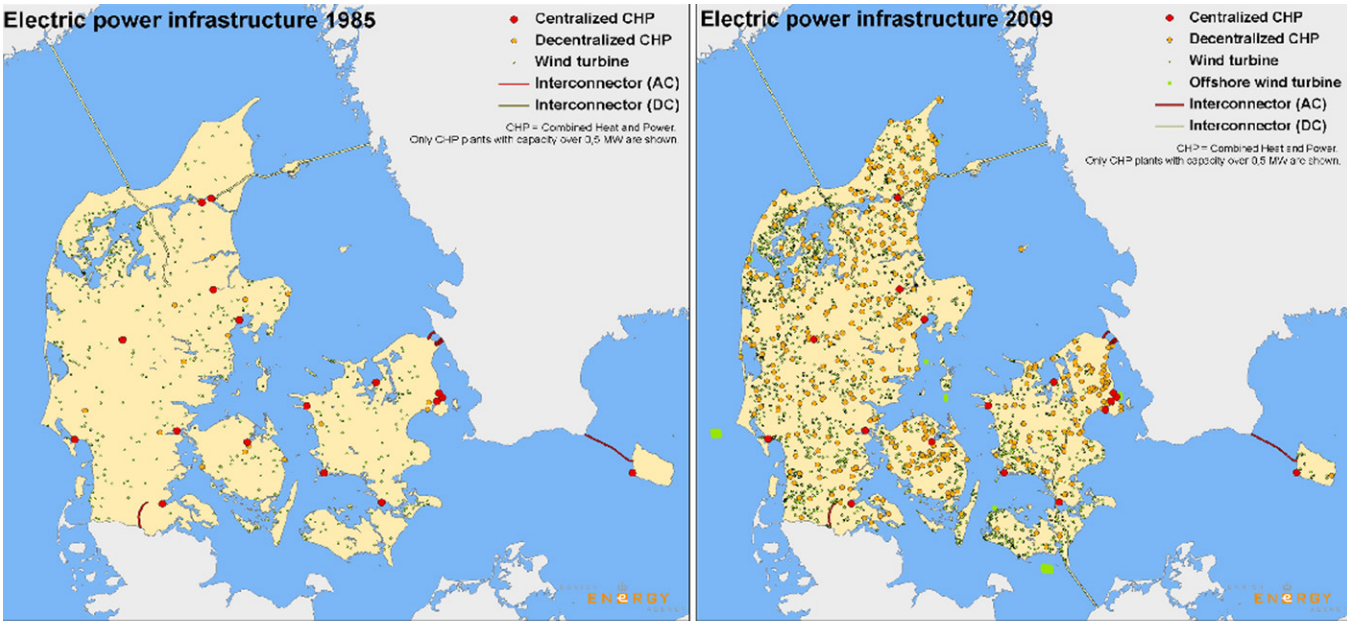


Fig. 5. Electricity Infrastructure in 1985 and 2009.

Source: [9].

Heat and Power (CHP) Plants in Denmark as major domestic electricity production components, while in 2009 it has been equipped with a number of decentralized CHP, wind turbines and offshore wind (Fig. 5)

In addition to this, database of International Energy Agency and [2] have pronounced that despite of having 6.4 GW of peak demand during 2003, the domestic generation capacity of the country was 13.3 GW [2]. It means that the country has some evidences of having surplus and over generation capacity, which can be managed in a scientific manner through current and future growing population and demand. Furthermore, of the domestic generation capacity of electricity of 2003, wind accounted for 3.1 GW (23%). Furthermore, the flexibility in the Danish power plants' (i.e. some thermal plants have multi-fuel system, which can burn coal, oil, gas, biofuels and municipal waste) can potentially offer sound space in the energy management in future as well. Provision and availability of international interconnections like Nordic Pool, connection with Sweden, Germany are also regarded as one of the important tools for the country to boost its energy management in future. Likewise, the domestic transmission for the flow of energy for internal usage is highly facilitated with a 600 MW direct current (DC) line, which is built to connect eastern and western part of the country [2].

Apart from this, energy efficiency improvement and energy saving measures are also some important initiatives of the country, which is one of the supportive tools in reducing overall energy consumption in the buildings, industrial process, pumping and others, where majority of the total energy consumption do occur. The final Action Plan of September 2005 estimates the total potential energy savings available in the Danish economy and has elaborated that with attractive energy pricing, with today's technology, it has saving potentiality of at least 10% of current energy consumption.

This may even go for nearly 25% in the next one decade, if equipment, processes and buildings are being improved, maintained or replaced. With the development of efficient technologies for energy conversion, production, distribution and on use, the country may have even higher energy saving potentiality. Some of the energy saving potentials as indicated by "Action Plan for renewed energy conservation efforts" and cited by [2] is shown in Table 4. The energy saving potential of the country hence is also one of such tools that supports the country embark to the green energy future.

In the same context, when we look after the previous scenarios of energy consumption of the country, it reveals that the country's ratio of final energy consumption to the gross energy consumption is in increasing trend, particularly from early 90s (Fig. 6). This may be as a result of improved energy management, energy savings with the technological development, energy shift and judicial use of energy in different applications.

There has been significant achievement in the utilization of available energy from different energy carriers to perform different activities in the country. About 3.6% of final energy consumption to the gross energy consumption ratio can be found during the entire period of 1980–2009. About 5.2% of this ratio has been increased from 1990 to 2009 (Table 5). This feature of Denmark however, still needs attention for more improvement, while considering the depleting fossil fuel, environmental problem and fulfilling its energy strategies. The Danish government strategies and policies for making the country 100% renewable energy consuming is expected to improve the conversion and utilization of energy in more efficient manner by 2050 [1,6,9].

As discussed earlier, in the past three decades, Denmark has maintained high economic growth with almost constant total energy consumption against its large-scale economic growth. Furthermore, there have been continuous shift of energy systems to renewable energy. In addition to this, availability of skilled manpower and technologies to deliver in energy efficiency and green energy technologies development is also one of the factors to help the country achieving this success [10]. These are among some strong basis, which support the target set by the Danish government to embark for green energy future.

4.3. Achievements in reducing emission (CO_2)

The CO_2 emission (adjusted) of the country utilizing different mix of fuel and in different usages in 1990 is reported to be 62,570 ('000 tonnes). On this stake, the level of CO_2 emission in the energy sector, transformation sector (power production) and final energy consumption (at end-use level) in 1990 were respectively 800, 28,809 and 32,881 ('000 tonnes).

Table 4
Potential for energy saving in various sectors.

End-use	Final energy consumption	Socio economic potential up to 2015		Private economy potential (%)	
	PJ	%	PJ	Currently	Up to 2015
Space heating	217.6	24%	51.3	18%	47%
Industrial processes	66.5	25%	16.5	13%	27%
Lighting	24	24%	5.7	19%	60%
Cooling/freezing	15.1	28%	4.3	10%	35%
Electric motors	12.4	15%	1.9	10%	30%
Ventilation	11.9	40%	4.8	13%	38%
Pumping	8.4	35%	2.9	14%	42%
Other	71.3	24%	17.2	11%	33%
Total	427.2	24%	104.5	16%	42%

Source: [2].

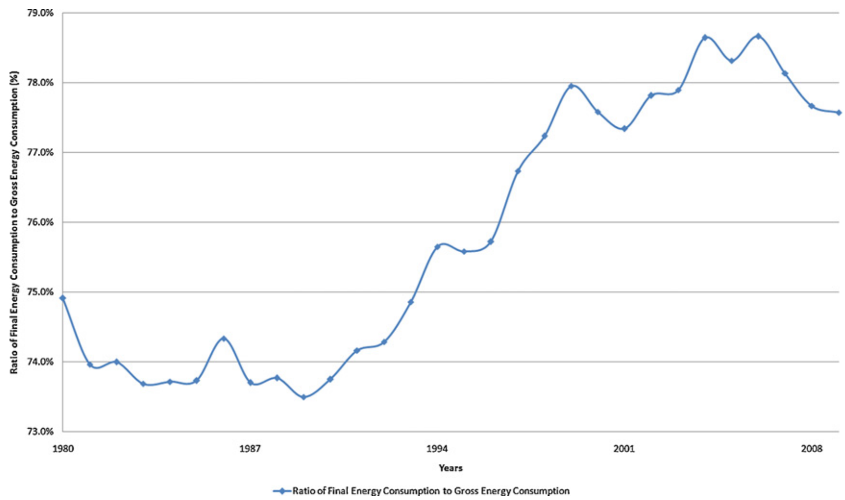


Fig. 6. Ratio of final energy consumption to gross energy consumption (1980–2009).

Source: Based on database [1,9].

Table 5
Ratio of final energy consumption to gross energy consumption of Denmark (1980–2009).

Adjusted [%]	1980–2009	1990–2009	2008–2009
Ratio of final energy consumption to gross energy consumption	3.6	5.2	−0.1

Source: [1].

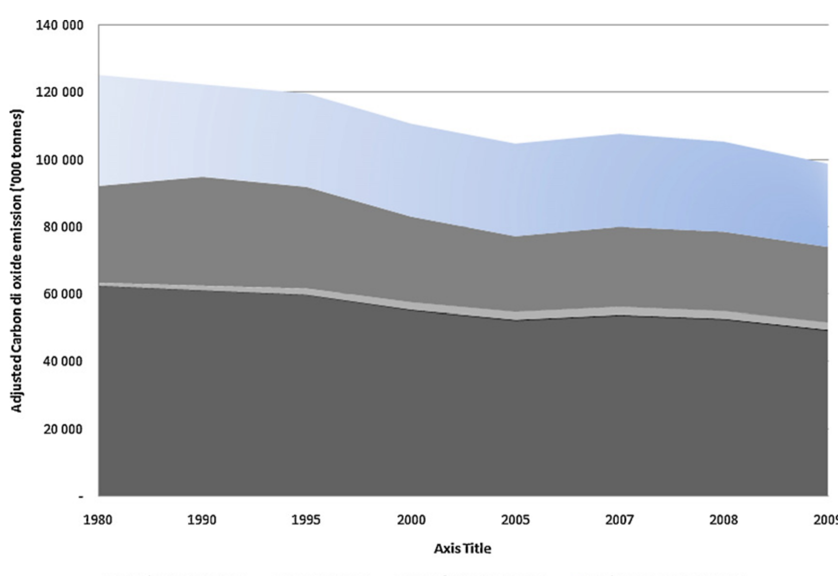


Fig. 7. Adjusted carbon dioxide emission in Denmark (1980–2009).

Source: Based on database [1,9].

Table 6
Summarizing energy facts of Denmark (1980–2009).

	1980	1990	1995	2000	2005	2008	2009
Energy intensity, gross energy consumption [TJ per DKK Million GDP, 2000 Prices]	0.998	0.818	0.748	0.649	0.618	0.601	0.595
Gross energy consumption per capita [GJ]	159	160	161	157	157	158	148
Final energy consumption per capita [GJ]	119	118	122	122	123	122	115
Degree of self-sufficiency [%]	5	52	78	139	155	130	124
Dependency of oil [%]	67	43	45	45	41	39	39
Renewable energy – share of gross energy consumption [%]	2.9	6.1	7.0	9.8	14.7	16.6	17.5
Electricity capacity [MW]	6618	9142	11,045	12,598	13,091	13,157	13,410
Wind turbine capacity – share of total electricity capacity [%]	–	3.8	5.7	19.0	23.9	24.0	26.0
Net electricity exports – share of domestic supply [%]	5.1	−22.5	2.3	−1.9	−3.8	−4.0	−1.0
CHP production – share of total thermal electricity production [%]	18	37	40	56	64	56	55
CHP production – share of total district heating production [%]	39	59	74	82	82	78	77
Renewable energy – share of total domestic electricity supply [%]	0.0	2.0	5.9	15.3	26.3	26.7	27.4
CO_2 emissions per capita [tonnes]	12.2	11.9	11.5	10.4	9.7	9.6	9.0
CO_2 emissions per kWh electricity sold [g CO_2 per kWh]	1034	937	807	634	538	571	567
CO_2 emissions per consumed unit of district heating [kg CO_2 per GJ]	91	68	51	47	39	39	38
CO_2 emissions per GNP [kg per DKK]	77	61	53	43	38	37	36

Source: [1].

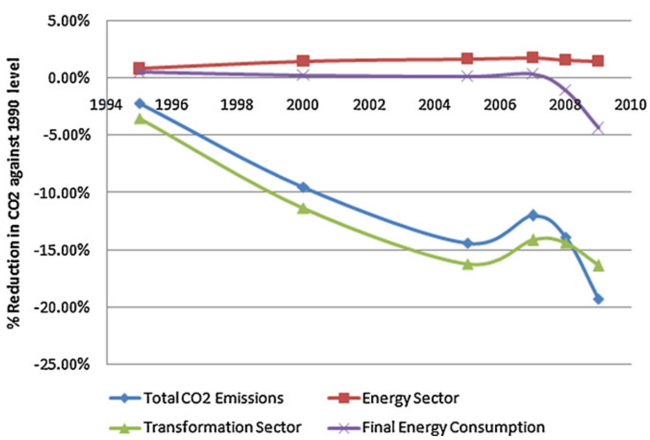


Fig. 8. Percentage reduction of carbon dioxide reduction compared to 1990 level. *Source*: Based on database [1,9].

A higher emission intensity have been prevailed at the end-use level, which is 10,440 ('000 tonnes) in 1990 for operating end-uses like transport; agriculture and industry; trade and services; and households. In the total CO_2 emission in 1990, the transport and agriculture-industry sector had been the major source, emitting 10,440 and 10,360 ('000 tonnes) of CO_2 [1,9].

Similarly, emission from end-uses like trade and service, and household were 2890 and 9191 ('000 tonnes) respectively in 1990 (Fig. 7). Whereas, in 2009 there have been increment in the CO_2 emission from the transportation sector, which was 22.59% than that of 1990 level. However, about 29% reduction of CO_2 emission had occur in agriculture and industry, followed by 48% in trade and service, and 45% in household sector [10,13].

In addition to this, with the development in the energy sector, the level of emission has been found in a decreasing trend in different subsequent years. It has been found that about 9.52% of the total CO_2 emission has been reduced than that of 1990 level by 2000, and about 14% in 2005, followed by 19% in 2009 (Fig. 8) [10,13].

5. Conclusion

Energy self sufficiency in the Denmark has been found characterized with ample of sound consideration on economically responsible transition from fossil fuel. The country has been progressively developing its infrastructure to harness renewable energy by tapping kinetic energy from wind resources, from sustainable biomass sources and other conventional energy base. Likewise, the share of wind energy production capacity to the total share of electricity capacity, which used to null in 1980 and only 19% even by 2000 is about 26% in 2009. Likewise, there have been progressive developments in up-scaling CHP, District heating system and contribution of renewable energy in the total domestic electricity supply in 2009 (Table 6).

Energy policy of the country has been found supportive in the energy management of the country, where high diversification of sources in the total energy demand has been practiced by 2009. Coal and natural gas each supplied around 20% of the gross energy consumption in 2009, which is lower in comparison to the past decades. The dependency on oil, which used to be 67% in 1980 has now drastically reduced to 39% in 2009, the share of renewable energy, which used to be only 2.9% in 1980 is about 17.5% in 2009 (Table 6).

The high share of cogeneration and district heating based on surplus heat has contributed significantly to the high efficiency, and enables rapid fuel switching. Overall, this means that the Danish economy today is significantly more robust and resistant to supply failures from single sources and suppliers as well as to large fluctuations in oil prices [13].

Finally, at the decades of acute oil crisis (1973), almost all developed countries made their attention on the nuclear power, then after continued to make a race for getting the shrinking fossil energy carriers, where at the same moment there has been high priority on energy efficiency and renewable energy by country like Denmark. This attitude towards the renewable energy and its wise management is hopefully had played a significant role to export energy technologies, which make up of 11% of its total export earnings in 2008, where there was no any export earnings through renewable energy technologies at the decades of 90s [10,11,13]. However, still when we observed the energy consumption and share of total emissions by transport sector, still special attention is required while embarking and fulfilling the strategy of green energy future of the country. The way for the greener energy future is particularly governed by the implementation functions of the strategies, the scale of laying infrastructures of renewable energy technologies, social acceptances and degree of flexibility of energy sources in potential renewable energy power system of the country. This needs careful implementation plan and judicious management of resources for the optimal use of energy.

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This review paper has been prepared with an objective to have a self understanding on the development of energy sector in Denmark. I am from Nepal and currently pursuing MSc course in Sustainable Energy Planning and Management at the Aalborg University of Denmark. The paper however is not able to capture all the details on energy dynamics of the country, like electricity market, electricity regulations, cross border energy transfer, renewable energy developments, and in depth analysis on energy savings measures on buildings, but is expected to be able for outlining how past and current efforts of the Danish government can play a vital role in fulfilling its energy strategies.

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